12.1 Respiration and Energy

Respiration is the process by which living organisms release energy from nutrient molecules, such as glucose.

Uses of Energy in Living Organisms

The energy released during respiration is vital for all life processes, including:

- **Muscle contraction** (for movement).
- **Protein synthesis** (for growth and repair).
- **Cell division** (for growth and asexual reproduction).
- **Active transport** (moving substances against a concentration gradient).
- **Growth** (producing new cells and tissues).
- **Passage of nerve impulses** (communication within the body).
- **Maintaining a constant body temperature** (in mammals and birds).

Investigating Respiration

An experiment can be carried out to **investigate and describe the effect of temperature on respiration in yeast**. This involves measuring the rate of carbon dioxide production (a product of yeast respiration) at different temperatures.

Result: An increase in temperature (up to an optimum) leads to an increase in the rate of respiration.

12.2 Aerobic Respiration

Aerobic respiration is the chemical reaction in cells that uses **oxygen** to break down nutrient molecules (glucose) to release a **large amount of energy**.

Feature	Description
Location	Cytoplasm and Mitochondria of cells.
Oxygen	Required (used).
Energy Release	Large amount of energy released.
Products	Carbon dioxide and water.

Word and Chemical Equations

- **Word Equation:** glucose + oxygen → carbon dioxide + water
- **Balanced Chemical Equation (Extended):** $C6H12O6 + 6O2 \rightarrow 6CO2 + 6H2O$

12.3 Anaerobic Respiration

Anaerobic respiration is the chemical reaction in cells that breaks down nutrient molecules (glucose) to release energy **without using oxygen**.

Feature	Description
Oxygen	Not required (absence of oxygen).
Energy Release	Much less energy released per glucose molecule than aerobic respiration.

Anaerobic Respiration in Yeast (Fermentation)

- **Word Equation:** glucose → alcohol + carbon dioxide
- **Balanced Chemical Equation (Extended):** $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$
- **Application:** This process is used in the brewing industry (to produce alcohol) and the baking industry (carbon dioxide causes bread to rise).

Anaerobic Respiration in Muscles

This occurs in human muscle cells during **vigorous exercise** when the blood cannot supply oxygen to the muscles fast enough.

- **Word Equation:** glucose → lactic acid
- **Lactic Acid Build-up:** Lactic acid builds up in the muscles and blood, causing muscle fatigue and pain. This build-up creates an **oxygen debt**.

Oxygen Debt (Extended)

The **oxygen debt** is the extra oxygen required after vigorous exercise to break down the accumulated lactic acid.

How the Oxygen Debt is Removed:

1. **Transport:** Continued fast heart rate transports the lactic acid in the blood from the muscles to the **liver**.
2. **Breathing:** Continued deeper and faster breathing supplies the necessary oxygen for this aerobic breakdown of lactic acid.
3. **Conversion:** In the liver, the lactic acid is converted back into glucose.
4. **Aerobic Respiration:** The glucose is then broken down **aerobically** (requiring oxygen) to release energy, or it is converted to glycogen for storage.